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SILURIAN AND DEVONIAN LIMESTONES OF WESTERN TENNESSEE.

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A. SILURIAN STRATA ALONG THE WESTERN FLANK OF THE CINCINNATI GEANTICLINE.

1. *In southern Indiana, Kentucky, and northern Tennessee.*—In southern Indiana[1] the Silurian strata are divided into the following beds, named in descending order:

Louisville limestone.
Waldron shaly clay.
Laurel limestone.
Osgood shaly clay.
Clinton limestone.

Southward, along the western flank of the Cincinnati geanticline, the equivalents of these beds may be traced with varying success even as far as northern Alabama.

The ease with which any beds may be traced for long distances depends greatly, of course, upon the constancy of their lithologic features. In this respect the subdivisions of the Silurian along the western flank of the Cincinnati geanticline are remarkable. Very little change is shown in the lithological characteristics of any of these subdivisions between southern Indiana and northern Tennessee. North and south of this area, however, the Osgood bed rapidly becomes more calcareous and is changed from a shaly clay to a soft limestone, weathering more readily than the Clinton limestone below or the Laurel limestone above. The Waldron bed also becomes calcareous northward, and is replaced by limestone in central Indiana. Southward it may be traced as far as northern Alabama, but in central and southern Tennessee it is only 3 to 4 feet thick, and along the middle part of the bed the clay is replaced by a layer of limestone, 6 to 10 inches thick. Both northward in Indiana and southward in Tennessee the Waldron bed maintains its characteristics as a shaly clay farther than the Osgood bed.

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[1] *Twenty-first* and *Twenty-second Annual Reports of the Indiana Survey*, for the years 1896, 1897.

The thickest sections of the Osgood bed are found in central Kentucky. Here the Osgood bed consists almost entirely of soft shaly clay, often 38 feet thick. In southeastern Indiana this clay is represented by the Lower Osgood clay. Along the Ohio River the Lower Osgood clay horizon usually consists of soft shaly clay, locally replaced by a more or less indurated clay rock. Northward the amount of induration increases, especially in the upper half of this horizon. Farther northward, beyond a line connecting Versailles and Vernon, lenses and nodular layers of limestone begin to appear in the upper half of the Lower Osgood clay horizon. Still farther northward, the calcareous element increases at all levels, so that at New Point the equivalent of the Lower Osgood clay consists of an inferior quality of limestone. Both the Osgood bed and the lower part of the Laurel bed are quarried here. The Waldron bed may be traced 15 miles farther northward, to Milroy, but at Sandusky and at various other localities a considerable quantity of thin limestone is interbedded with the clay.

At Bledsoe, in northern Tennessee,[1] the Osgood bed consists chiefly of soft clay. At South Tunnel most of this clay is more or less indurated. At Baker station the upper half of the bed contains sufficient crinoidal material to form an inferior quality of limestone. Along the Harpeth River the greater part of the Osgood horizon is occupied by more or less calcareous, indurated clay rock, grading into clayey limestone at the top and bottom. Locally, the larger part of the Osgood section may consist of soft clayey limestone. In central and southern Tennessee the Osgood bed consists of rather thin-bedded limestones, weathering back more readily than the Laurel bed above and the Clinton bed beneath. Here its identity can often be established only with difficulty. The Waldron bed maintains its character as a shaly clay horizon much farther southward than the Osgood bed. It is typically developed along the Harpeth River near Newsom. At this locality it contains a large part of the fauna characteristic of this horizon at Waldron, Ind. In central and southern Tennessee a thin bed of limestone, 6 to 10 inches thick, replaces the clay along the middle of the bed.

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[1] "Silurian and Devonian Limestones of Tennessee and Kentucky," *Bull. Geol. Soc. Am.*, 1901.

2. *Centreville, Riverside, and Iron City, Tenn.*—At Centreville the Devonian is represented, in descending order, by the phosphatic nodule layer, 4 inches thick; the Chattanooga black shale 4½ feet thick; and the Hardin sandstone, 8 inches thick. It rests unconformably upon soft shaly clay, the equivalent of the Waldron bed. The original thickness of the Waldron bed at this locality is unknown; at present the thickest section preserved beneath the Hardin sandstone is 2½ feet thick. Twenty-five feet are assigned to the Laurel bed. It is underlaid by limestone, 4 feet thick, which weathers badly and forms a transition between the more solid limestone above and the softer, more clayey limestone, 6 feet thick, beneath, which, stratigraphically, appears to belong to the Osgood horizon. The upper beds of the Clinton limestone are more solid and more or less cherty. They contain *Triplesia Ortoni*. Along the railroad only the upper part of the Clinton, 12½ feet thick, is exposed. Ordovician limestone, probably the Leipers Creek bed, occurs about 25 feet lower down. Since a part of the unexposed interval is probably occupied by the Mannie clay,[1] the total thickness of the Clinton at this locality cannot be determined. Across

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[1] In western Tennessee, west of the Central Basin, the following Ordovician beds named in descending order, have been recognized:

Cincinnati Group	Richmond	Mannie shale. Leipers Creek limestone.
	Lorraine	Warren limestone. Swan Creek limestone.
	Utica	Absent in western Tennessee.
Trenton Group	Trenton	Saltillo limestone, belonging to lower part of Trenton.
	Black River	Absent in the Tennessee River valley.
	Stones River	Wells limestone, belonging to the upper part of the Stones River; exposed in central part of Wells Creek basin; identified by Safford as the Knox dolomite.

The Cincinnati Group in Western Tennessee, between the Tennessee River and the Central Basin. JOUR. GEOL., January-February, 1903.

the bridge northeast of town there is an exposure of Clinton limestone, 20 feet thick.

At Montgomery's Mill the limestone referred to the Laurel bed is 28 feet thick: the Waldron bed, 4 feet; the Louisville bed, 25 feet thick, is unconformably overlaid by the Black shale series; the original thickness of the Louisville bed at this locality is therefore unknown.

South of Centreville no exposures extending from the Ordovician to the Waldron horizon are known until Riverside, 25 miles distant, is reached. The upper part of the Mannie clay, 5 feet 9 inches thick, is exposed northwest of Riverside, on the western side of the Buffalo River, immediately north of the railroad bridge. It is overlaid by a massive bed of limestone, 5 feet 9 inches thick, strongly cross-bedded, very ferruginous in places, referred to the Clinton horizon. Several hundred yards north of the bridge, at the base of a large bluff, the top of this cross-bedded limestone contains Silurian fossils. Here the Clinton is overlaid by soft, rather thin-bedded limestone, 4 feet thick, weathering back. A slight unconformity exists between this soft limestone and the layers immediately above. The soft limestone beneath this line of unconformity probably occupies the Osgood horizon, although the base of the Laurel bed at this locality is also soft, and weathers back, so that it cannot be distinguished lithologically from the Osgood bed. Immediately north of the railroad bridge the Osgood bed appears to be absent; this is probably due to the unconformity already mentioned.

Immediately above the cross-bedded Clinton, north of the railroad bridge, the base of the Laurel bed contains numerous specimens of *Pisocrinus gemmiformis*, one specimen of *Holocystites* 4 inches long, and several specimens of large species of *Orthoceras*. At the cliff, farther northward, the thickness of the limestone referred to the Laurel bed is 36 feet 3 inches. The upper half of this limestone is more massive, and some of the courses are slightly reddish in color; the lower part is softer and weathers back. The Waldron bed is 3½ feet thick, and consists, in ascending order, of clay, 14 inches thick; soft white crumbling limestone, 6 inches thick, containing *Bilobites biloba;* and clay, 22 inches thick. Only the lower part of the Louisville bed, 5 feet 8 inches thick, is exposed. It consists of massive limestone overlaid unconformably by a layer of chert, 8 inches thick. At the large quarries between Riverside and Mannie this layer of chert is overlaid by phosphatic nodules, some of them 4 inches long, followed by brown sandstone, 8 inches thick, containing traces of fish remains.

The coarse, cross-bedded, ferruginous limestone identified as Clinton contains recognizable Silurian fossils only at the top. The possibility therefore exists that further research may prove the greater part of this rock to be of Ordovician age, although for the present it is regarded as equivalent to the Clinton.

The section at Iron City, just north of the state line of Alabama, closely resembles that at Riverside. The best exposures occur directly north of the town, at Cedar Point, along the western side of the railroad branch to Pinckney. The top of the Mannie clay is exposed at various points at the level of the railroad. The total thickness is unknown, but probably exceeds 16 feet, this being the distance of the exposures above the creek. The coarse-bedded ferruginous limestone, 2½ feet thick, was formerly extensively mined. It is overlaid by cherty rock, varying from 2 to 12 inches in thickness, and containing species of Silurian fossils identical with those in the upper part of the Clinton bed at Riverside. The coarse-bedded rock at Cedar Point contains very few recognizable fossils, and the few found belong apparently to new species. For the present it is referred to the Clinton, the cherty bed at the top being regarded as its summit. The Clinton is overlaid by soft, red, clayey limestone, 3 feet thick, weathering back, and referred to the Osgood horizon. Above this is more solid limestone, 23 feet thick, referred to the Laurel horizon. In general it is white, but within 3 or 4 feet of the base it is usually more or less strongly tinged with red. The Waldron bed is 3 feet thick, and as at Riverside consists, in ascending order, of clay, 1 foot thick; white crumbling limestone, 5 inches thick; and clay, 18 inches thick. Only the lower part of the Louisville bed, 19 feet thick, is present. It consists of hard, white limestone, and was formerly quarried at Cedar Point. It is unconformably overlaid by brown rock, 2 feet thick. At the Taylor quarry, one and a half miles northeast of Iron City, along the railroad line to Columbia, the Louisville bed is extensively quarried. It is unconformably overlaid by the Black shale series, consisting, in ascending order, of deep brown shaly rock, 6 inches thick; greenish, fine-grained Hardin sandstone, 15 inches thick; fissile Chattanooga black shale, 6 inches thick; greenish shale similar to the greenish shales above the black shale southwest of Mount Pleasant, 10 inches thick; and a layer of phosphatic nodules. In the railroad cut through Iron city, now abandoned, some of the heavier beds in the lower part of the Waverly contain plant remains.

The coarse, cross-bedded limestone at Riverside and Iron City, referred to the Clinton, suggests that these localities were not far distant from the shoreline at the beginning of the Silurian period. This suggestion is apparently corroborated by an outcrop about half a mile east of Cedar Point. Here the road leading eastward from Cedar Point crosses the railroad to Columbia. In a dry run along the southern side of the road, about a hundred feet east of the railroad, a coarse conglomerate bed, about 1 foot thick, is exposed. Some of the pebbles are 3 inches long. This conglomerate is referred to the Clinton. It rests upon a bluish, thin-bedded limestone, interbedded with more shaly material, referred to the Ordovician.

Careful search in the valleys of Brush and Bluff Creeks, northeast of Waterloo, in Alabama, failed to reveal any Devonian, Silurian, or Ordovician rocks in the areas credited with rocks beneath the Subcarboniferous horizon, on the geological map of Alabama, published in 1894.

B. SILURIAN STRATA IN THE TENNESSEE RIVER VALLEY.

I. CLINTON, OSGOOD, LAUREL, AND WALDRON BEDS.

3. *New Era, Glenkirk, Clifton, Swallow Bluff, Maddox mill, Waynesboro.*—The most northern exposures of Ordovician rocks along the Tennessee River occur between the mouth of Cedar Creek and New Era.

On the road leading from Kelley Landing to New Era, north of the branch north of Bee Creek, the Saltillo limestone is overlaid by Richmond limestone, 17½ feet thick, followed by crinoidal fine-grained limestone forming the base of the Silurian.

Along the Dry Branch, directly north of New Era, the Saltillo limestone is overlaid by Richmond limestone, 12½ feet thick. The Richmond limestone is of a bluish color. At the top it is very coarse-grained, consisting chiefly of fragments of brachiopod shells. The base of the Silurian is formed by a hard, white, massive limestone, 20 feet thick. The lower and middle part of this bed is more crinoidal. The upper third is more dense, and where weathered has a greenish-brown tint, similar to that shown by the cherty Clinton at Clifton. No characteristic fossils were discovered in the bed at New Era. Stratigraphically, however, the bed occupies the same position as the beds referred to the Clinton at Clifton, Riverside, and Iron City. Overlying the hard white Clinton limestone along the road leading east from New Era is a soft reddish limestone, 6½ feet thick, referred to the Osgood, followed by reddish limestone interbedded with whitish layers, a section 3 feet thick, also referred to the Osgood and evidently forming a transition to the Laurel limestone. The Laurel limestone, 27 feet thick, is a rather hard, well-bedded, reddish limestone. The Waldron bed is about 3½ to 4 feet thick. As in the case of the exposures at Riverside and Iron City, the shales along the middle of the Waldron bed are replaced by a layer of very white limestone, 9 inches thick.

At the foot of the bluff northwest of Glenkirk, three miles north of Clifton, the Richmond limestone is overlaid by a considerable thickness of Mannie clay, also of Richmond age. The massive white limestone at the base of the Silurian section, referred to the Clinton, is only 3 feet 9 inches thick. It contains *Illaenus Daytonensis*. The Clinton is followed by soft, reddish limestone, 12 feet thick, weathering back, referred to the Osgood. Overlying this is a more solid reddish limestone, 3 feet thick, forming a transition to the solid Laurel limestone immediately above. The Laurel Limestone is reddish as at New Era and northward. It is 21½ feet thick. The Waldron bed is

3 feet thick. As at all other localities in southern Tennessee, it consists of three layers, in ascending order: soft clay containing a calcareous rubble, 18 inches thick; hard limestone, 6 inches thick; and soft red clay, 1 foot thick.

At Clifton the Saltillo limestone is overlaid by the Warren bed, a cherty limestone, 3 feet 4 inches thick. This bed has so far not been identified elsewhere in the Tennessee River Valley. The Warren bed is overlaid by the Richmond limestone, 19 feet thick, followed by the Mannie clay, 15½ feet thick. North of the landing the Clinton limestone is exposed. It is 1 foot thick, and consists chiefly of greenish-brown chert, although part of the bed is often less siliceous and is more of the nature of ordinary limestone. The color of this limestone varies usually between white and light brown, but a small part of it is tinged with salmon-brown. Both the limestone and chert is fossiliferous. The fauna has a general resemblance to that found in the Clinton of Indiana and Ohio. The presence of *Lichas breviceps clintonensis*, *Calymmene vogdesi*, *Cyrtoceras* (*Glyptoceras*) *subcompressum*, *Orthoceras ignotum*, and *Cypricardinia undulostriata* may be mentioned. The occurrence of *Cyrtoceras subcompressum* is of special interest, since it indicates that this species has a much wider geographical range than hitherto suspected. Immediately above the Clinton at Clifton there is a series of comparatively thin beds of clayey, reddish limestone, 14 feet thick, referred to the Osgood horizon. *Pisocrinus gemmiformis* and *Stephanocrinus osgoodensis* occur within 2 feet of the base of the Osgood bed, and their range extends from this point through the Osgood into the Laurel. They are especially abundant in the harder limestone, 2½ feet thick, which forms the base of the Laurel bed. Near the middle of the Osgood bed there are several layers full of very large, coarse, crinoid stems. They contain also various undescribed species of *Illaenus*, *Lituites*, *Orthoceras*, *Hyolithes*, *Cyclonema*, and *Platyceras*. *Atrypa reticularis* is also present. *Caryocrinus ornatus*, the typical form, occurs at this level and also within 2 feet of the top of the Osgood bed. Large specimens of *Orthoceras* occur at all levels, as usual at this horizon in central and southern Tennessee. The Laurel bed consists chiefly of hard, reddish-purple limestone. Its thickness has not been determined at this locality. No attempt has been made as yet to identify the Waldron bed within the town limits at Clifton. However, the Waldron bed is well exposed along the river bank, a quarter of a mile above the old cement mill. It is here about 3 feet thick, and consists, in ascending order, of whitish clay, about 8 inches thick; white, very dense limestone, about 8 inches thick; and indurated clay, white below, red above, containing most of the fossils collected. Attached to the top of the white limestone bed were found eight specimens of *Eucalyptocrinus magnus*, and six specimens of *Eucalyptocrinus elrodi*, fossils characteristic of the Waldron bed, and found in great abundance at this horizon at Newsom. Only 16 feet of limestone belonging to the top of Laurel bed are exposed beneath the Waldron at this locality. It is very hard and has a reddish-purple color. The total thickness of the Laurel bed at this locality is unknown.

At Swallow Bluff, about half-way between the mouths of Hardin and Indian Creeks, on the north side of the Tennessee River, the Saltillo limestone is directly overlaid by the Silurian. At the base of the Silurian section there is hard, whitish limestone, 18 inches thick, with scattered specks of black chert, followed by a layer of black chert, 2 to 8 inches thick; both are fossiliferous, and are referred to the Clinton bed. The layer of chert is overlaid by hard, massive white limestone, 8½ feet thick, followed by thin-bedded white limestone, 9½ feet thick, and a softer, more clayey rock, partly tinged with red, 5¼ feet thick. The softer, clayey limestone, partly tinged with red, occupies in a general way the horizon of the Osgood bed. It is overlaid by hard limestone, 28 feet thick, referred to the Laurel bed. The lower part, 6 feet thick, is white and crackled. The middle and upper part is more reddish-purple. The most massive layers are near the top. Above the Laurel bed is the Waldron, 3½ feet thick, well exposed along the upper part of the bluff below the landing, immediately above the broad shelf formed by the top of the Laurel bed. The Waldron bed consists, in ascending order, of soft whitish clay, 14 inches thick, containing small fragments of rubble limestone; very fossiliferous, hard, white, dense limestone, 6 inches thick, the fossils not readily recognizable; and reddish clay, 20 inches thick, containing most of the fossils collected.

Along Horse Creek no exposures of Richmond limestone or Mannie clay have been found, although a single specimen of *Rhynchotrema capax manniensis* was collected in the very thin layer of residual clay intervening between the Saltillo limestone and the Silurian at Maddox mill. The Saltillo limestone is exposed for more than a mile along Willoughby Creek, at the old Lick Ford, near its mouth, and at the Maddox mill. At the mill the lower part of the Silurian, 2 to 7 feet thick, is hard and cherty, and is referred to the Clinton. Above it is massive limestone, 23 feet thick, bluish near the base, white throughout the rest of the section. This massive limestone corresponds stratigraphically to the white limestone section, 18 feet thick, which overlies the layer of chert at Swallow Bluff. The Osgood, Laurel, and Waldron beds have, so far, not been identified along Horse Creek. No exposures have been found at the proper horizons.

At the home of W. D. Helton, about 3½ miles northwest of Waynesboro, on Beech Creek, the Saltillo limestone is well exposed. The Richmond limestone, 7 feet thick, is seen several hundred yards up stream, on the south side of the creek. The Mannie clay is probably 20 to 25 feet thick. The base of the Silurian section forms a cliff on the north side of the creek, about 100 yards farther up stream. The Mannie clay beneath the cliff is weathered back, and immediately above there is almost a foot of ferruginous material, very much weathered, which may represent the ferruginous chert at the base of the Silurian in other sections. Immediately above is massive limestone, 6½ feet thick; followed by massive, bedded limestone, 8½ feet thick; and well-bedded limestone, 12½ feet thick; a total of 27½ feet corresponding stratigraphically to the Silurian limestone exposed at the Maddox mill. Immediatelely above, for a distance of 10 feet, there is no exposure. The total thickness of the Silurian section at the W. D. Helton locality is 104 feet. A careful search along the bluffs lining the creek will, no doubt, reveal the position of the Waldron bed. Until this has been accomplished the stratigraphy of the Silurian at this locality must remain more or less in doubt.

Along the western flank of the Cincinnati anticline, the Osgood bed is reduced to a thickness of 3 or 4 feet. This is shown by the exposures at Riverside and Iron City. With the exception of the exposures in the immediate vicinity of Clifton, the thickness of the Osgood bed is small also along the Tennessee River in southern Tennessee. At the base of the Silurian section at Swallow Bluff, Maddox mill, and W. D. Helton, also at New Era and Kelley Landing, there is a considerable section of limestone, usually whitish in color, massive at the base, and more distinctly bedded near the top. This limestone occurs below the beds referred to the Osgood horizon. It thins out at Glenkirk and Clifton. It apparently thins out also from the W. D. Helton locality toward Riverside and Iron City. The base of the section, at least, is equivalent to the Clinton. The top may belong to the Osgood horizon. The position of the intermediate part is doubtful. It is evident that the plane of division between the Clinton and the Osgood beds is rising southward and that the lithological divisions here do not correspond strictly to those farther north and northeast. For the present the name Maddox limestone may prove convenient for the massive limestone in question.

II. LEGO AND DIXON BEDS.

4. *Nomenclature.*—Along the western flank of the Cincinnati geanticline, in southern Indiana, Kentucky, and Tennessee, the name Louisville bed has been given to the Silurian rocks overlying the Waldron bed. In the Tennessee River valley, in western Tennessee, the Silurian section overlying the Waldron bed is so thick that it has been found necessary to subdivide it.

At the base is a series of limestones, varying from 30 to 45 feet in thickness, to which the name *Lego limestone* is here given. Stratigraphically, this bed occupies the same position as the Louisville bed. Its paleontological equivalence, however, has not yet been determined, owing to the small number of fossils so far obtained in the Lego limestone. Overlying the Lego limestone is a series of red clays, 30 to 45 feet thick, to which the name *Dixon clay* is given. This clay has so far proved comparatively unfossiliferous, *Fistulipora* (*Thecostegites*) *hemispherica* being the only fossil so far found in abundance. Above the Dixon red clay is a section of white limestones and clays, exceeding 100 feet in thickness. This section is often richly fossiliferous and contains the fauna studied by Roemer during his three weeks visit to Decatur county, Tennessee. To this section overlying the Dixon red clay, the name *Brownsport bed* is here given.

Lithologically, the limestones forming the middle and lower part of the Lego bed often resemble those forming the Laurel bed so much that, in the failure to identify the Waldron horizon, it is impossible to distinguish the same. In that case, the name *Glenkirk limestone* may be used to designate the combined Laurel-Lego section.

5. *New Era, Glenkirk, Clifton, Cerro Gordo, Paulks, Sulphur Spring, Martin's mill, Rise mill, Pegram.*—At New Era, along the road leading eastward from the landing, the Waldron bed is overlaid by whitish limestone, 22 feet thick, followed by alternating layers of whitish and reddish limestones, 10 feet thick; a total of 32 feet, referred to the Lego bed. The Dixon red clay bed is 37 feet thick, and consists of partly indurated, dark brick-red clay. The base of the Brownsport bed is formed by a layer of white clay, 2 feet thick. The nearest post-office is at Lego, about a mile and a half up the river.

At Glenkirk, the Waldron bed is overlaid by a layer of massive limestone, 3½ feet thick; bedded limestone, 12½ feet thick; a reddish clayey layer, ½ foot thick; rubble and solid limestone, 21½ feet; a total of 36 feet, referred to the Lego bed. The Dixon red clay is 22½ feet thick, and is overlaid by the white clay layer forming the base of the Brownsport bed.

Along the slope of the hill back of Clifton, north of the road to Waynesboro, the Dixon red clay bed was estimated to have a thickness of 44 feet.

About a third of a mile above the old cement mill at Clifton, along the river bank, the Waldron bed is overlaid by crackled limestone, 31½ feet thick, followed by similar limestone including layers of reddish clayey rock, 14½ feet thick, a total of 46 feet, referred to the Lego bed. The Dixon bed is 42½ feet thick. It consists chiefly of red, clayey rock, but contains also layers of whiter rock. It is overlaid by the layer of white clay, 1½ feet thick, forming the base of the Brownsport bed.

About a quarter of a mile southeast of Cerro Gordo, at the Cave Spring on the road to Savannah, the upper part of the Lego limestone, 28 feet thick, is exposed above the spring. Along the road leading up hill there is red clayey rock, 35 feet thick, referred to the Dixon bed. At the Landing at Cerro Gordo the white clay layer at the base of the Brownsport bed is underlaid by a layer of massive, indurated clay, 2 feet thick, and this, in turn, by a section 26 feet thick, red and clayey at the top, less red and clayey below, consisting near the base of fairly solid limestone. Beneath this is whitish limestone, 42 feet thick. It is difficult to determine where to draw the line between the Dixon and the Lego bed.

On Horse Creek, about a quarter of a mile below the Paulk or Watson mill, at a cave locally well known, there is a section of red clay and limestone, 34 feet thick, which may belong to the Dixon bed. The top of this section is exposed at water's edge at the mill. As in the case of the section at the Cerro Gordo landing, there is only a general resemblance to the Dixon bed.

A lithologically more typical exposure of the Dixon red clay rock is seen at the Sulphur Spring on the Ike Ross and Arnold place, about a mile above Dodd's mill. Here the Dixon bed is 35 feet thick. It is overlaid by the white clay layer forming the base of the Brownsport bed, and underlaid by white limestone, 5 feet thick, forming the top of the Lego bed.

The Dixon bed is exposed about half a mile north of Martin's mill, on the northern bank of Indian Creek, directly opposite the site of the old Craven mill. It here consists of about 44 feet of reddish clay and clayey limestone, overlaid by the white clay layer forming the base of the Brownsport bed. The top of the Lego limestone is well exposed about a mile down stream.

At the Webb or Rise mill, 1½ miles south of Linden, reddish rock about 11 feet thick, forms the base of the section. It may belong to the top of the Dixon bed.

The red phase of the Dixon bed has not been seen anywhere east of a line connecting Martin's mill and Rise mill. The upper part of the Silurian section at W. D. Helton, 3½ miles west of Waynesboro, probably belongs to this horizon, but it does not have a red color, nor is it a conspicuously clayey section. The horizon of the Dixon bed must be represented by some of the rocks exposed along the headwaters of Buffalo River, west of Riverside; but, if so, they do not possess the strong, brick-red coloring shown by the Dixon bed farther westward.

The exposure at Montgomery's mill is too low to include the Dixon horizon.

At the bridge, 1½ miles west of Pegram, the base of the Brownsport bed is represented by a layer of clay, 8 feet thick, including thin fragments of limestone. This clay contains the typical Brownsport fauna. Beneath it is a section of clayey limestone, white or bluish in color, which evidently must weather readily into a sort of clay, since it is exposed only along the railroad cut. The thickness of this clayey limestone cannot be determined definitely, owing to the irregular dip, but it is known to exceed 22 feet and may equal 40 feet. It is considered the equivalent of the Dixon bed. Northeast of the railroad cut, up Furbee and Greer Hollow, well-bedded limestone flags represent the top of the Lego bed. The Lego bed is at least 28 feet thick, a mile and a half east of Pegram, in the bluffs southeast of the home of Sam Walker. Its total thickness is unknown.

It is evident that the red color is characteristic of the Dixon bed only in the Tennessee River sections. Even in the Tennessee River basin the red color is due chiefly to weathering, the less weathered sections exposed by the more rapid cutting of streams consisting more frequently of beds of red rock alternating with layers of whitish limestone. It some sections the whitish limestone equals, or even slightly exceeds, the red clayey rock in quantity. Where weathered, the whitish limestone is tinged more or less strongly with red.

There is usually no sharp line of demarkation between the Lego limestone and the Dixon red clay. A series of transition beds almost always connects the more typical parts of the section. The change from the solid limestone to the reddish clayey rock takes place in different sections at different levels, so that it is evident that parts included in the Dixon bed in one section may be represented by hard limestone in another section, and may there be included in the Lego bed. The Lego and Dixon beds may therefore be regarded as one horizon, bounded by the Waldron bed below, and the Brownsport bed above, changing from a series of limestones beneath to a series of clayey rocks, usually red in the Tennessee River basin, above.

6. *West of the Tennessee River.*—Both the Lego bed and the Dixon bed are exposed at many points between Swallow Bluff and Perryville. At Swallow Bluff the lower part of the Lego bed, 28 feet thick, is exposed along the river, below the landing. At Bath Spring the top of the Dixon bed is 67 feet above the level of the spring. West of New Era the Dixon bed is well exposed along the road from Vice's store to Brownsport Furnace. At the furnace, south of the store, *Orthoceras amycus* occurs 15 feet below the top of the Dixon bed. The Dixon bed is well exposed at the base of the mound glade, a quarter of a mile north of the home of Noah Butler, 2½ miles north of Vice. Exposures of both the Dixon clay and the Lego limestone are common within 2 miles of Dixon Spring. The Dixon bed usually forms the lower part of the glades so frequent in this part of Tennessee. No attempt has been made to determine the thickness of these beds on the western side of the Tennessee River.

According to Professor Safford, the reddish limestone below the Dixon bed is quarried on Birdsong Creek in Benton county, and in the southern part of Henry county, on the Big Sandy River, where a local but a wide dome brings this bed to the surface.

III. BROWNSPORT BED.

7. *Eastern line of outcrop.*—The most eastern exposure of the Brownsport bed is at the bridge, 1½ miles west of Pegram, and about 21 miles east of Dickson. Here the base of the Brownsport bed, consisting of clay, 8 feet thick, is directly overlaid by the Mesodevonic limestone, most nearly related to the Onondaga or Corniferous. At Montgomery mill, the top of the Silurian

exposure is formed by the Lego bed, 25 feet thick, directly overlaid by the Hardin sandstone. The Brownsport bed is probably exposed several miles farther down the river. At Riverside only the base of the Lego bed, 6 feet thick, is exposed. The westward dip of the strata at this point, however, is so great that 3 miles farther westward, at an exposure about a quarter of a mile south of the home of Ed. Walker on the east side of Tucker branch, the Brownsport fauna is found in a calcareous clay about 14 feet below the Hardin sandstone. It includes such characteristic species as *Favosites Forbesi discoidea* and *Pisocrinus milligani; Fistulipora hemispherica* is also present. Northwest of Flatwoods, at the mouth of Little Opossum Creek, the Silurian exposure is 48 feet thick, and is directly overlaid by the Hardin sandstone. *Thecia major* occurs at the top; *Calceola tennesseensis* was found 9 feet below the top; *Astraeospongia meniscus,* 12 feet below the top; all are Brownsport fossils. The Dixon bed is not exposed; it is therefore impossible to determine whether it retains its red color as far eastward as Flatwoods.

The Brownsport bed was not detected at the W. D. Helton locality, 3½ miles northwest of Waynesboro, on Beech Creek; the total Silurian section is here 104 feet, and the top cannot be far beneath the base of the Brownsport bed. The Silurian here is directly overlaid by the Hardin sandstone. The Silurian bed is exposed about 6 miles west of Waynesboro, on the south side of Hardin Creek, where the road from Waynesboro to Dr. Yeiser and Martin's mill crosses Brewer Branch. It consists chiefly of white clay with some limestone, about 20 feet thick, and contains *Fistulipora hemispherica.* It is directly overlaid by the Hardin sandstone, 11 feet thick. South of this locality, west of the home of Dr. E. R. Yeiser, 6 miles east of Martin's mill, the clay and crumbling limestone immediately beneath the Hardin sandstone contains *Astraeospongia meniscus* and *Uncinulus stricklandi.* The presence of the sponge indicates the Brownsport horizon. Brownsport fossils occur in the white clay, 3 feet thick, which overlies the Dixon bed at the Sulphur Spring on the Ike Ross and Arnold place on Horse Creek. It is not exposed farther eastward along the southern boundary of Tennessee, but probably extends under cover as far as Whittens Stand.

On the geological map of Alabama published in 1894, Chattanooga black shale and Ordovician limestone are recorded as occurring in the valleys of Brush (Four Mile), and Bluff Creeks, southwest of Whittens Stand, within 6 miles of the Tennessee state line. A careful examination of these valleys revealed nothing lower than the Subcarboniferous. At the Taylor quarry northeast of Iron City, the lower part of the Lego bed, 19 feet thick, is directly overlaid by the Black shale series, and, at another locality, by the Waverly.

West of the line of eastern outcrops here enumerated the Brownsport bed is exposed at the proper horizon at all points where not removed by Cretaceous and Tertiary erosion. The thickest sections are found farthest westward in that part of the area in which the Brownsport bed is directly overlaid by the Chattanooga black shale series. This is evidently the area east of the line of outcrop of the Linden or Helderbergian limestones and shales. A study of the outcrops within this area indicates that the Brownsport bed is unconformably overlaid by the Chattanooga black shale series. If the thinning out of the Brownsport bed eastward is due to erosion in times preceding the Mesodevonic, the Brownsport bed may formerly have extended much farther eastward, up the western flank of the Cincinnati geanticline.

8. *Perryville, Linden, Lego, New Era, Clifton, Cerro Gordo, Brownsport.*—At Perryville the upper part of the Brownsport bed is quarried. *Astraeospongia meniscus* occurs at the top, immediately beneath the Linden limestone. The upper part of the Brownsport bed is formed by hard limestone also a mile north of Linden, north of the home of William Patton, and thence eastward, forming a bluff 52 feet high along a branch entering the Buffalo River. Here *Astraeospongia meniscus* occurs again at the top, immediately beneath the Linden limestone, associated with *Caryomanon stellatim-sulcatum.* On Coon Creek, within a mile of the Buffalo River, east of the home of William Goodwin, the Brownsport section is 88 feet thick. It is overlaid by the Hardin sandstone, and 78 feet below the top contains *Conchidium lindenensis.* At the Webb or Rise mill the Black shale series is

underlaid by a Silurian section, 85 feet thick, belonging to the Brownsport horizon, and 11 feet of reddish rock only doubtfully referred to the Dixon bed. Although the Linden bed is not present, the top of the Brownsport bed at this locality is stratigraphically equivalent to the top of the Brownsport bed north of Linden. The most striking characteristic of the exposures near Linden is the fact that the Brownsport bed, as far as exposed, consists chiefly of limestone, and shows comparatively little tendency to weather into clays. It does not form glades, and at no point displays the great wealth of brachiopods and sponges characteristic of the lower part of the Brownsport bed farther southward. At the entrance of Jacks Branch into Short Creek, east of the home of E. Duncan, numerous corals are found 18 feet below the Hardin sandstone.

Northeast of Lego, on Short Creek, 300 yards southeast of the homes of W. E. Ashley and P. Denman, the Hardin sandstone, 6 feet thick, is underlaid by 60 feet of limestone belonging to the Brownsport bed. The top contains *Uncinulus stricklandi* and *Gypidula roemeri;* 43 feet below the top *Conchidium legoensis* occurs. Along the road leading east from New Era the lower part of the Brownsport bed, for a thickness of at least 30 feet, forms a glade containing numerous specimens of *Astraeospongia meniscus*, and also specimens of *Astylomanon cratera* and *Caryomanon stellatim-sulcatum.*

In the area included between Perryville, Linden and Lego, the glade forming part of the Brownsport bed appears to belong chiefly to the base of the section, while the upper part is represented chiefly by comparatively unfossiliferous limestones.

At Glenkirk and back of Clifton only the base of the Brownsport bed, with a rather abundant fauna, is preserved. Along the river, three quarters of a mile above Clifton, the Dixon clay is overlaid by an exposure of the Brownsport bed 100 feet thick. The lower part, 25 feet thick, is cherty and full of fossil sponges. The middle part, 50 feet thick, consists chiefly of soft limestones, weathering to clay; it is evidently composed of material which on long exposure would be glade forming. The upper part, 25 feet thick, consists of harder limestone. At the top of the Brownsport bed a form of *Caryocrinus ornatus* occurs.

The rock exposures along the river at Savannah belong to the Glenkirk horizon. The Brownsport bed, overlying red rock, is exposed at Cravens, and also a mile farther down the river, at Cerro Gordo. At the latter locality the Brownsport exposure is 25 feet thick and richly fossiliferous. Above Saltillo the Glenkirk bed is seen again. The Saltillo limestone occurs along a creek southwest of town a little over a mile. At the landing, a well 50 feet deep struck plenty of undoubted Chattanooga black shale. The richly fossiliferous glade region of the Tennessee River valley region between Swallow Bluff and Perryville offers numerous exposures of the Brownsport bed. Swallow Bluff is situated on the north side of the Tennessee River, about halfway between the mouths of Indian and Hardin Creeks.

At Brownsport Furnace, about two miles west of Vice's store, the Brownsport beds, 120 feet thick, forms two glades, south of the old furnace. The southern glade exposes the lower part of the Brownsport bed resting on the Dixon red clay. The northern glade exposes the middle and upper part of the Brownsport bed. At the base of the northern glade occur several beds of limestone containing *Strophonella roemeri* and *Platyceras brownsportensis*. Immediately above, the clay is richly fossiliferous. The horizon occurs about 50 feet above the Dixon bed. Owing to the dip of the rocks, the actual vertical interval is about 35 feet. Fossils occur also at other elevations. The most interesting horizon is formed by the upper 20 feet of the section. At the top corals are numerous. Immediately beneath the coral horizon occur *Atrypa arctostriatus*, *Rhipidomella lenticularis*, and *Rhynchonella lindenensis*. Various silicified sponges belonging to species common in the Brownsport bed occur, loose, at the very top of the exposure. The Chattanooga black shale was exposed by excavations for ore along the hillside northwest of the old furnace. There is no evidence of the presence of the Linden bed at this locality.

9. *Dixon Spring; localities visited by Roemer.*—The Dixon Spring, located on the old Colonel Wallis Dixon farm, 3 miles south of Perryville, is in the midst of classic ground, since the collections of Silurian fossils made by Roemer during his five

weeks' visit to Decatur county were made within a radius of 5 miles from this locality. The Brownsport mentioned in his report is Brownsport Landing, on the Tennessee River, about 5 miles southeast of Dixon Spring, and 3 miles north of Vice Landing. The furnace at this landing was erected in 1839–40. The furnace west of Vice Landing, at present known as Brownsport Furnace, was not put up until 1849, two years after Roemer's visit. The mound glade mentioned in his report as occurring about 1 mile west of Brownsport Landing can no longer be identified. Several mound glades are known within a mile and a half of the old Brownsport Landing. A mound glade is any conical hill capped by the whitish clays and soft limestones of the Brownsport bed. These whitish calcareous clays, for some reason, form soils which are very unfavorable to the growth of most plants. A scanty growth of grass, a considerable number of cedars, and a few stunted oaks, too low to be called trees, usually occupy a comparatively small part of the exposures, leaving most of the hillside open. These open spaces on the hill sides are known as *glades*. Owing to the white clays, these glades are visible for long distances and are often conspicuous landmarks. At the base they are often edged with red, owing to the presence of the Dixon bed. One of these mound glades occurs about a quarter of a mile north of the home of Noah Butler, on the road from Vice to Perryville, 2½ miles north of Vice. Another, not exposing the Dixon bed, occurs about half a mile farther west. Here the Brownsport bed has a thickness of at least 93 feet. Fortunately the identification of the mound glade of Roemer is a matter of little importance, since the species cited from this locality occur at numerous localities elsewhere. Several glades occur on the road leading eastward from Dixon Spring to the river, and numerous glades occur south and southwest of the spring, within the radius of a mile. Glades are also found between Dixon Spring and Perryville, but most of the exposures near the road belong to the Glenkirk and Dixon beds. All of the species described by Roemer were obtained in the glades and therefore belong to the Brownsport horizon.

10. *Bath Springs; Colonel Smith, 4 miles east of Economy; Gant*

place.—Three localities belonging to the Brownsport horizon were referred by Professor Safford with some hesitation to the Helderbergian or Linden limestone.[1] These are Bath Springs, the Colonel Smith locality, and the A. B. Gant locality.

The Bath Springs are located about a mile and a half east of Martin's store, and about the same distance northwest of Martin's Landing; the springs are situated in the valley south of the home of W. N. Davis, and the Silurian exposures occur north of the house. The top of the Dixon bed occurs 67 feet above the level of the springs; it is the top of the *Variegated bed* of Safford. It is overlaid by shaly limestone, 17 feet thick, containing *Astraeospongia meniscus* (Layer A); hard limestone, 4 feet thick; white clay and soft limestone, 22 feet thick (Layer C), containing the fauna investigated by Safford; hard limestone, 7½ feet thick; softer layers of rubble limestone, 19 feet exposed, containing *Caryomanon, stellatim-sulcatum, Fistulipora hemispherica, Enterolasma waynense*, and *Rhipidomella saffordi*. The Silurian is immediately overlaid by the iron-ore gravels of Safford. The absence of the Helderbergian at the Rise mill and at Lego makes it possible that it may have been absent in times preceding Tertiary erosion also at Bath Springs.

The Colonel Jim Smith locality is situated about 9 miles east of Savannah on the road to Waynesboro. The property now belongs to John Godwin. The exposure consists of clay and soft limestone covering the slope between the house and the road, and extends for a short distance both east and west along the road. Numerous brachiopods characteristic of the Brownsport horizon occur. The absence of the sponges so characteristic of the Brownsport bed at many localities probably caused the difficulty in the identification of this bed. About a mile west of the Colonel Smith locality, east of the home of Jim Irwin, numerous corals associated with *Astylomanon verrucosum* are found along the road. Half a mile farther west, east of the home of George Wilson, the brachiopod fauna seen at the Colonel Smith locality is associated with *Astylomanon verrucosum*, in a bed of whitish clay and soft limestone. Half a mile westward, in front of the home of J. H. Johnson, *Pisocrinus milligani* and other characteristic Brownsport fossils occur in hard limestone layers. The clayey fossiliferous bed is exposed also about a quarter of a mile south of the Colonel Smith locality, on the south side of Boone Creek, along a road leading up hill. It is here overlaid by more solid limestone.

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[1] Geology of Tennessee, par. 849.

The old A. B. Gant homestead is located about a mile northeast of Martin's mill. The fossils studied by Safford were obtained a quarter of a mile east of the house, on the hill slope 200 yards northeast of the plantation stables. A considerable interval, stratigraphically, separates the Hardin sandstone,[1] which here is the sole representative of the Black shale series, from the layer of massive, coarse, gray, sandy limestone, 10 feet thick (Layer 3), which furnished the fossils. Owing to weathering, great slabs of the Hardin sandstone have slipped down the hillside until almost in contact with the coarse sandy limestone. However, at a gully farther eastward, and also near the schoolhouse on Indian Creek, still farther eastward, the intervening section is clearly exposed. The existence of a considerable interval between the Hardin sandstone and the coarse sandy limestone was recognized by Professor Safford at Craven's mill (par. 845), where the exposures are better. At this locality the massive, sandy limestone and the overlying Silurian section (2) was referred by Professor Safford provisionally to the Helderberg limestone, but in the statement preceding the list of Helderberg fossils (par. 849) he states that it may be found desirable upon further investigation to refer these beds to the Niagara horizon. For purposes of discussion it will be found convenient to apply the name *Gant limestone* to the coarse sandy limestone under discussion, and the term *Gant bed* to the top of Silurian section including the Gant limestone at its base.

The former site of Craven's mill was located about half-way between the A. B. Gant homestead and Martin's mill, a short distance east of the point where the road following Indian Creek turns southward toward Martin's mill. Almost directly opposite this bend of the road, the Gant limestone is 10 feet thick. An

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[1] *Ibid.*, par. 844, Layer 4.

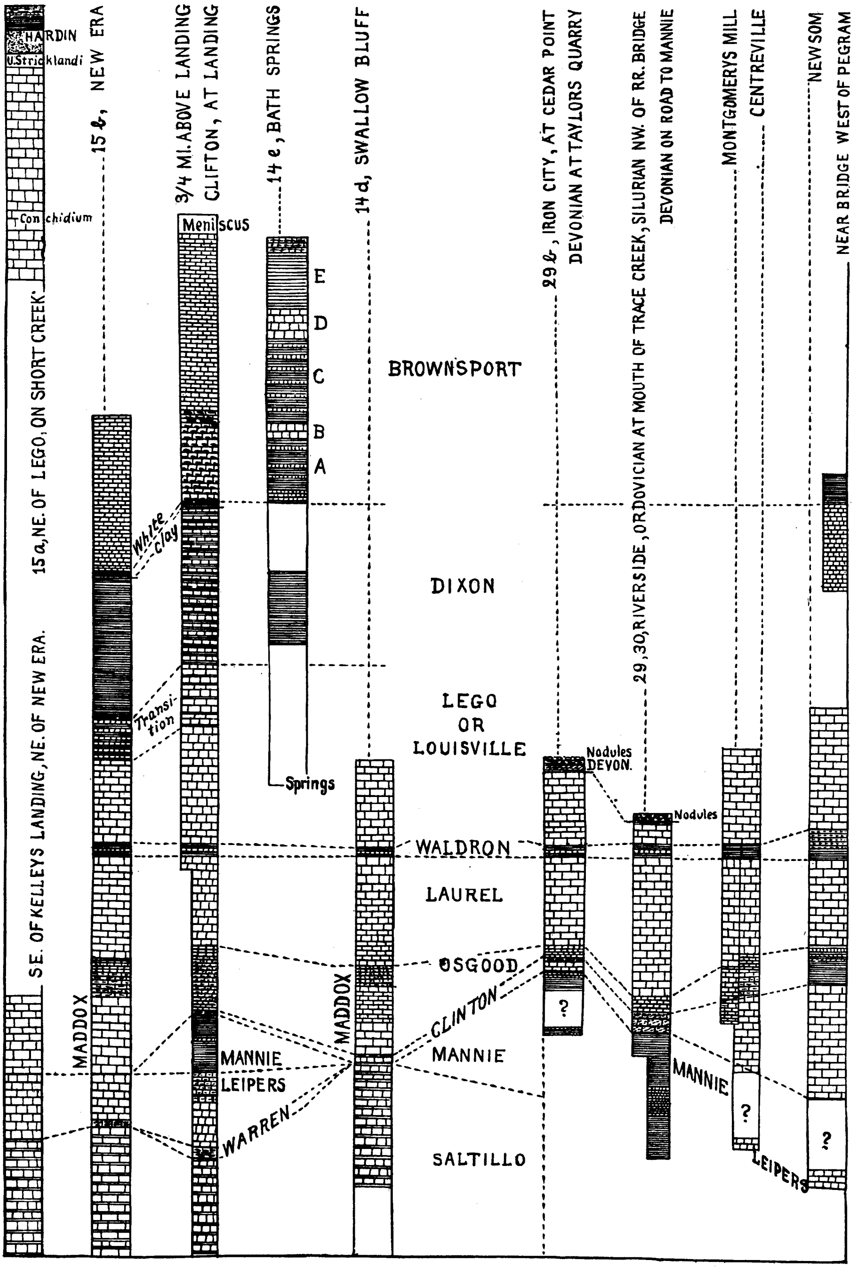

FIG. 1.—Sections between Newsom and Iron City, and between Swallow Point and New Era.

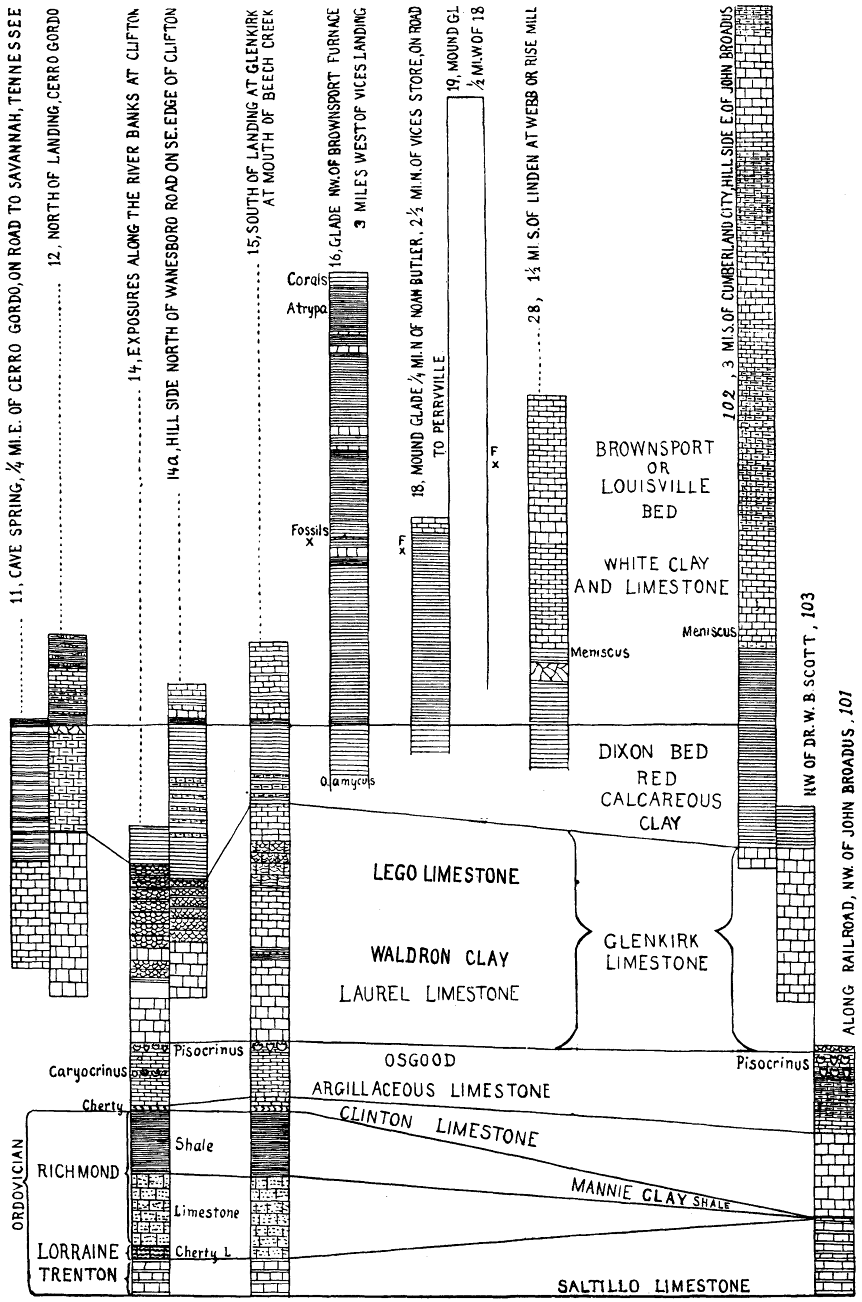
11, CAVE SPRING, ¼ MI. E. OF CERRO GORDO, ON ROAD TO SAVANNAH, TENNESSEE
12, NORTH OF LANDING, CERRO GORDO
14, EXPOSURES ALONG THE RIVER BANKS AT CLIFTON
14a, HILL SIDE NORTH OF WANESBORO ROAD ON SE. EDGE OF CLIFTON
15, SOUTH OF LANDING AT GLENKIRK AT MOUTH OF BEECH CREEK
16, GLADE NW. OF BROWNSPORT FURNACE 3 MILES WEST OF VICES LANDING
18, MOUND GLADE ¼ MI. N OF NOAH BUTLER, 2½ MI. N. OF VICES STORE, ON ROAD TO PERRYVILLE
19, MOUND GL ½ MI. W. OF 18
28, 1½ MI. S. OF LINDEN AT WEBB OR RISE MILL
102, 3 MI. S. OF CUMBERLAND CITY, HILL SIDE E. OF JOHN BROADUS
NW OF DR. W. B. SCOTT, 103
ALONG RAILROAD, NW. OF JOHN BROADUS, 101
Corals
Atrypa
Fossils x
F x
F x
O. amycus
Meniscus
Meniscus
BROWNSPORT OR LOUISVILLE BED
WHITE CLAY AND LIMESTONE
DIXON BED
RED CALCAREOUS CLAY
LEGO LIMESTONE
WALDRON CLAY
LAUREL LIMESTONE
GLENKIRK LIMESTONE
Pisocrinus
Pisocrinus
Caryocrinus
OSGOOD
ARGILLACEOUS LIMESTONE
Cherty
CLINTON LIMESTONE
Shale
ORDOVICIAN
RICHMOND
Limestone
MANNIE CLAY SHALE
LORRAINE
Cherty L
TRENTON
SALTILLO LIMESTONE

FIG. 2.—Sections along the Tennessee River, and in the Wells Creek Basin.

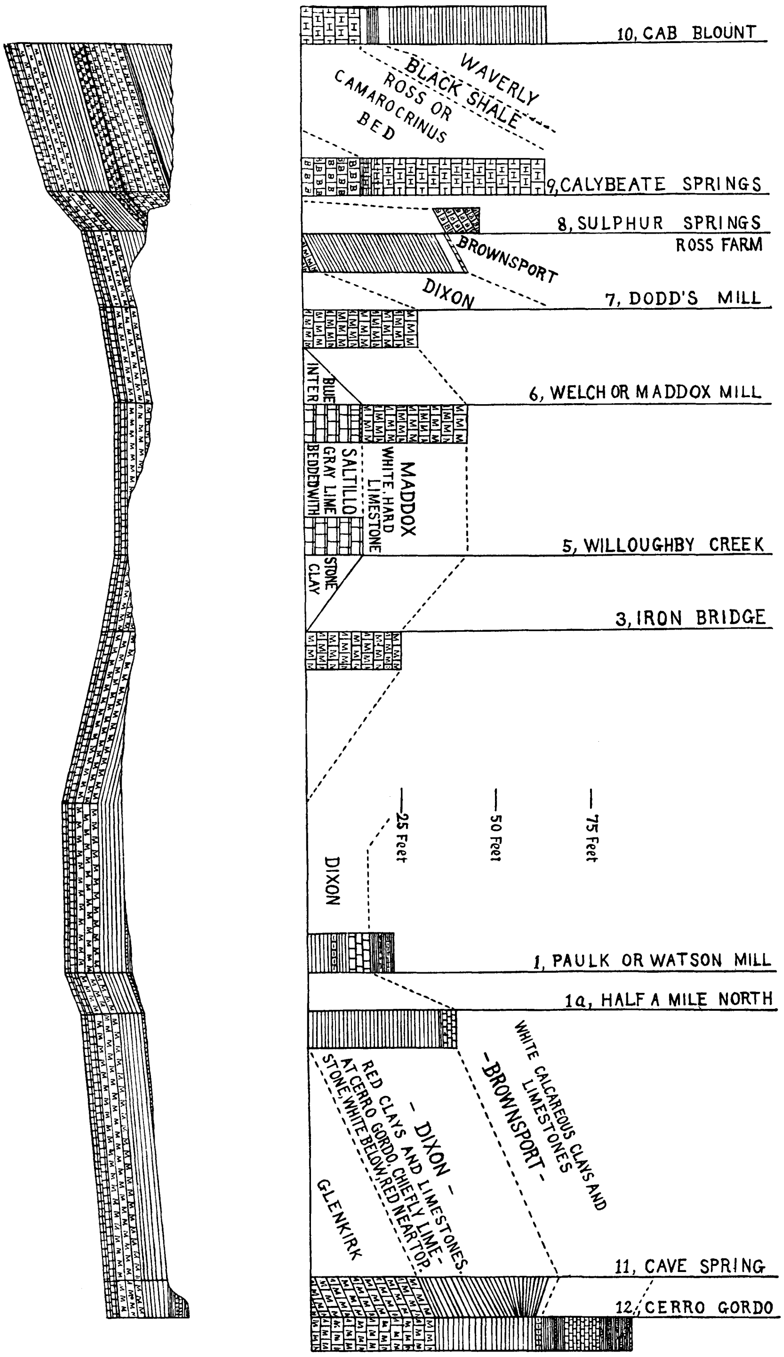

FIG. 3.—Sections along Horse Creek. In the lower figure the general relation of these sections is indicated on a different scale. The Glenkirk limestone overlies the Maddox limestone, and their combined thickness is greater than here represented.

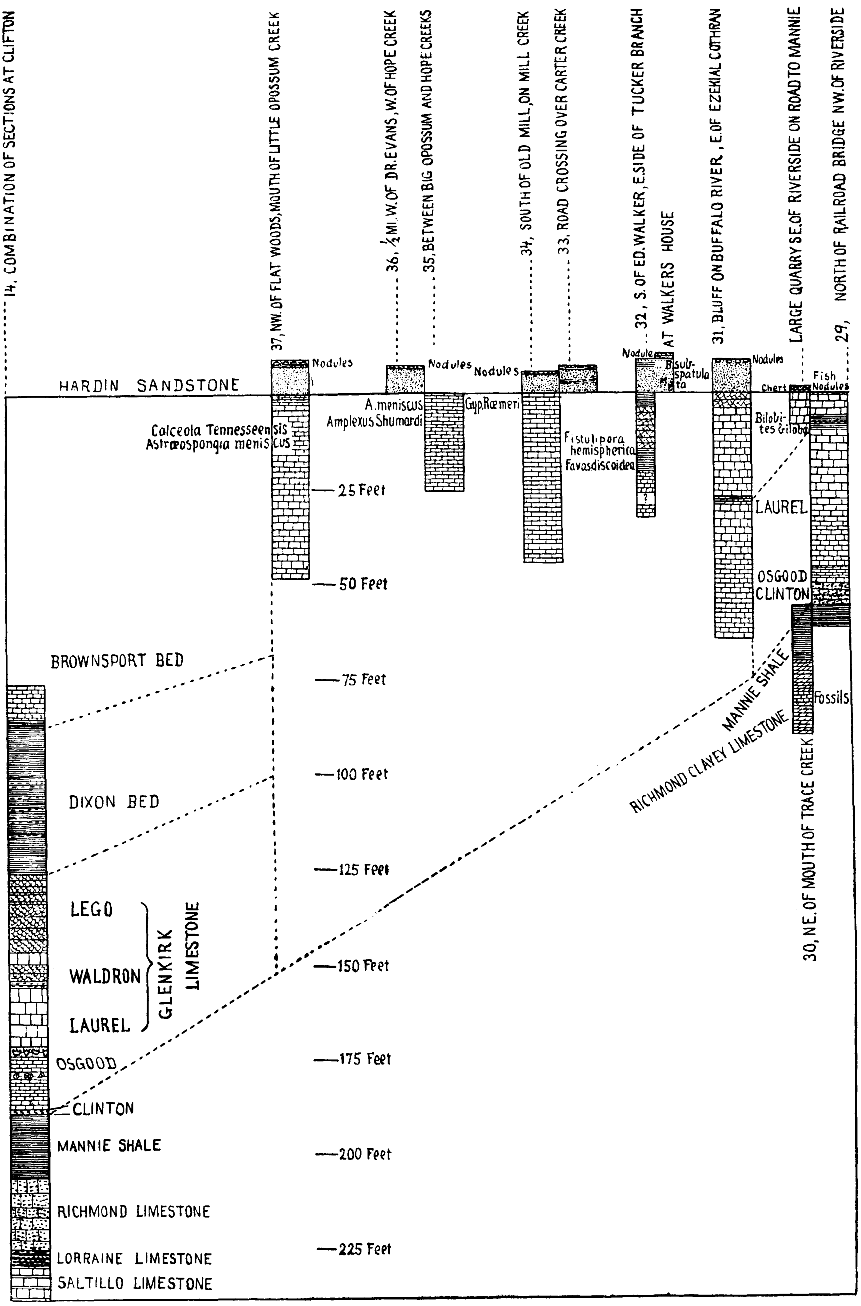

FIG. 4.—Sections between Riverside and Flatwoods.

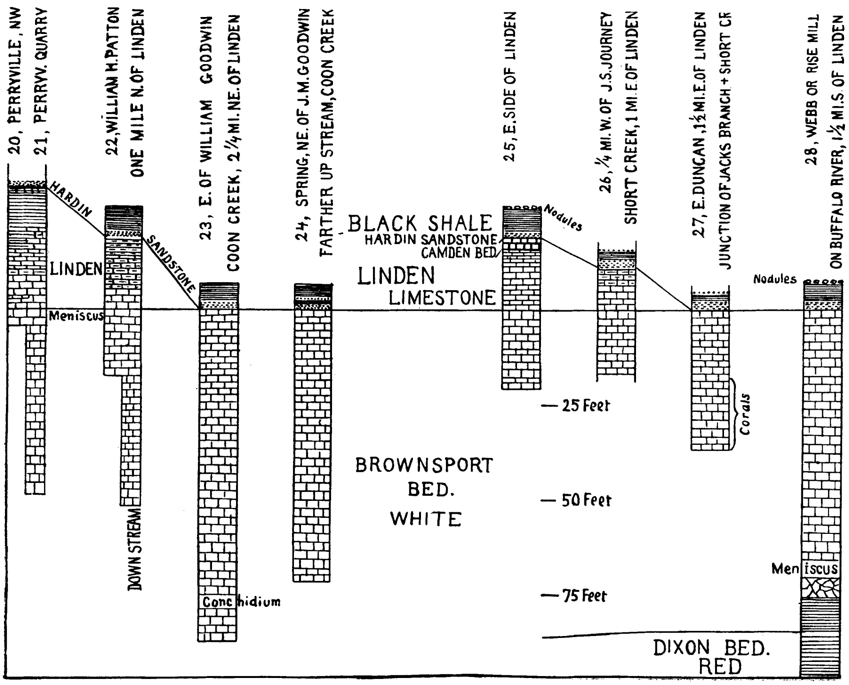

FIG. 5.— Sections at Perryville and Linden.

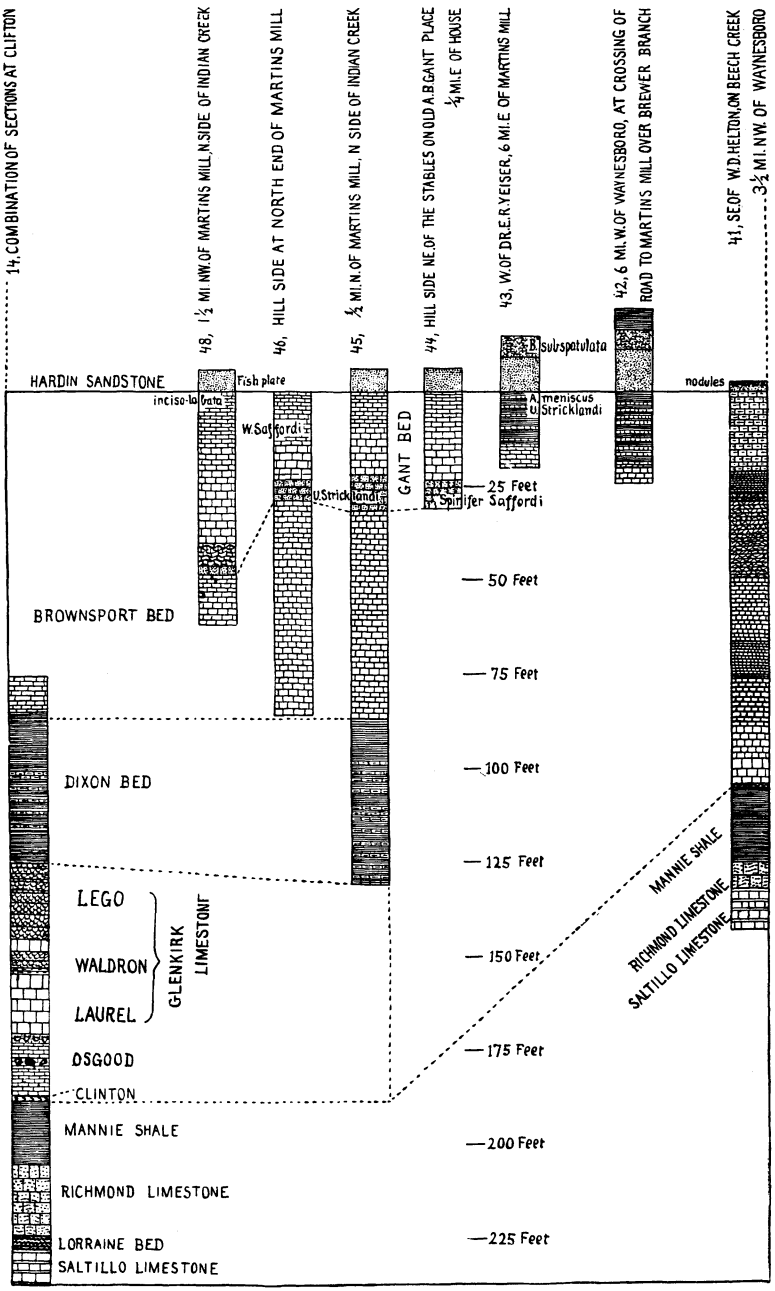
14, COMBINATION OF SECTIONS AT CLIFTON
48, 1½ MI. NW. OF MARTINS MILL, N. SIDE OF INDIAN CREEK
46, HILL SIDE AT NORTH END OF MARTINS MILL
45, ½ MI. N. OF MARTINS MILL, N SIDE OF INDIAN CREEK
44, HILL SIDE NE. OF THE STABLES ON OLD A.B. GANT PLACE ¼ MI. E OF HOUSE
43, W. OF DR. E.R. YEISER, 6 MI. E OF MARTINS MILL
42, 6 MI. W. OF WAYNESBORO, AT CROSSING OF ROAD TO MARTINS MILL OVER BREWER BRANCH
41, SE. OF W.D. HELTON, ON BEECH CREEK 3½ MI. N.W. OF WAYNESBORO
HARDIN SANDSTONE
inciso-lobata
Fish plate
B. subspatulata
A. meniscus
U. Stricklandi
nodules
W. Saffordi
GANT BED
U. Stricklandi
25 Feet
Spirifer Saffordi
BROWNSPORT BED
50 Feet
75 Feet
DIXON BED
100 Feet
125 Feet
LEGO
WALDRON
LAUREL
GLENKIRK LIMESTONE
150 Feet
MANNIE SHALE
RICHMOND LIMESTONE
SALTILLO LIMESTONE
OSGOOD
175 Feet
CLINTON
MANNIE SHALE
200 Feet
RICHMOND LIMESTONE
LORRAINE BED
225 Feet
SALTILLO LIMESTONE

FIG. 6.—Sections between Waynesboro and Martins Mill.

interval of 22 feet separates the limestone from the Hardin sandstone.

A very instructive exposure occurs on the hillside rising above the northeastern part of the cluster of houses known as Martin's mill. Here the sandy Gant limestone (Layer A) is found 57 feet above the road, and about the same distance above the Dixon bed. It is 5 feet thick and forms a projecting ledge. Overlying it is found a bluish, better bedded limestone, partly fine-grained and partly crinoidal, 9 feet thick (Layer B). Following this is more limestone, much weathered and poorly exposed, 14 feet thick (Layer C).

The whitish clays and soft limestones beneath the Gant limestone contain the sponges, brachiopods, and crinoids characteristic of the glade exposures of the Brownsport bed. At the A. B. Gant locality, the Gant limestone contains *Spirifer saffordi*, *Dictyonella gibbosa*, *Nucleospira concentrica*, *Wilsonia saffordi*, *Uncinulus stricklandi*, *and Orthothetes subplanus*. Some of these fossils occur also in the Gant limestone at the northeastern edge of Martin's mill, and at various exposures along the northern bank of Indian Creek, down stream.

In the overlying, more distinctly bedded limestone, Layer B, at Martin's mill, are found *Wilsonia saffordi*, *Uncinulus stricklandi*, *Orthothetes subplanus*, *Gypidula roemeri*, *Camarotoechia neglecta*, *Nucleospira concentrica*, and *Meristina maria roemeri*.

In the poorly exposed limestone at the top of the section, Layer C, occur *Astylospongia praemorsa*, *Caryomanon stellatim-sulcatum*, *Meristina maria roemeri*, and *Wilsonia saffordi*. About a mile below Martin's mill, northwestward, on the northern side of Indian Creek, *Caryomanon incisolobatum* was found within a foot of the Hardin sandstone.

A. F. FOERSTE.

[*To be continued.*]